METHODS AND PRACTICES FOR PRODUCING CRUSHED GRANITE, WESTON-BROOKER CO., WARREN COUNTY, GA.

BY NORMAN A. PACE AND HAROLD J. SCHROEDER

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METHODS AND PRACTICES FOR PRODUCING CRUSHED GRANITE, WESTON-BROOKER CO., WARREN COUNTY, GA.[1]

by

Norman A. Pace[2] and Harold J. Schroeder[3]

INTRODUCTION

This paper is one of a series being published by the Federal Bureau of Mines on methods and practices used in mining and preparing crushed stone for market. Performance, in terms of units of work or tons produced per machine and per operator man-hour, is given whenever that information can be obtained. Direct operating costs are useful for comparing different methods and are included, if available. In addition to describing equipment and methods used, the Bureau considered it desirable to discuss the engineering reasons for the choices that have been made.

This paper is particularly concerned with operation of the Camak quarry and plant of the Weston-Brooker Co. The quarry and plant are near Cedar Rock, north of State Highway No. 80 and east of Middle Creek in Warren County, Ga., and about 40 miles west of Augusta. Rail access is by a spur line of the Georgia Railroad from Camak, 5 miles southwest. The main office of the company is at Cayce, S. C.

ACKNOWLEDGMENTS

The writers appreciate the cooperation and assistance of the staff of Weston-Brooker Co. in preparing this paper. Special acknowledgment is made to W. S. Weston, president; R. A. Hemphill, plant superintendent; and S. Brunson, assistant plant superintendent.

BRIEF HISTORY AND EARLY DEVELOPMENT

Weston-Brooker Co. began quarrying at the Camak site in 1929. Because of the large body of granite partly exposed on the sides and top of a dome-shaped hill rising 130 feet above the elevation of Middle Creek, the company was attracted to this site, which offered promise in production of crushed-rock aggregates.

1/ Work on manuscript completed August 1958.
2/ Chemical engineer, Bureau of Mines, Region V, Norris, Tenn.
3/ Mining engineer, Bureau of Mines, Region V, Norris, Tenn.

Quarrying was accomplished first by benching into the exposed granite at a convenient point about 40 feet above the elevation of Middle Creek. Lateral expansion continued on this level to the present quarry limits of about 52 acres. Increased overburden, property boundaries, existence of powerlines, and roads were factors influencing the choice to develop the quarry at lower levels. Three 30-foot benches make the present floor 90 feet below the original floor elevation.

Early production records are not available, but by 1952 the plant's rated annual capacity was nearly 1,000,000 tons of quarried stone. Expansion of facilities at that time increased capacity to about 1,400,000 tons. The estimated total tonnage of stone removed from the quarry is 14,500,000 tons.

GEOLOGY AND PHYSICAL PROPERTIES OF THE GRANITE

The quarry is along the southeastern edge of the Piedmont Plateau. Geologically, this province is described by Watson[4] as a complex of highly metamorphosed sedimentary and igneous rocks of Paleozoic and pre-Paleozoic age. Extensive areas of both granite and granite-gneiss exist that are suitable for aggregate. Commercially, both types are called granite.

Dr. V. J. Hurst of the Georgia Department of Mines, Mining, and Geology describes the rock at the Camak quarry as a coarse-grained, biotite granite in which a faint gneissic structure is visible. Its mineralogic composition is as follows:

Mode of the coarse-grained granite at Camak

Point count	Volume-percent
Quartz	32.5
K-feldspar	19.5
Oligoclase	36.2
Myrmekite	1.4
Biotite	9.1
Chlorite	.6
Titanite	.3
Sericite	.2
Opaques	.2

The Georgia Department of Highways lists the stone from this quarry as having a specific gravity of 2.66 and an abrasive loss of 34 percent, using the Los Angeles test method (ASTM test C 131-51). Table 1 gives a more complete tabulation of physical-property determinations.

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[4] Watson, T. L., Granites of the Southeastern Atlantic States: Geol. Survey Bull. 426, 1910, p. 35.

TABLE 1. - Physical property data,[1] Camak quarry, Weston-Brooker Co.

GROUP 1

(Test specimens normal to foliation)

Property	Average value	Standard deviation, percent	Number of readings
Density:			
Apparent specific gravity	2.67	± 1	17
Density .... lb. per cu. ft.	167	-	-
Porosity .... percent	.38	±15	4
Strength:			
Compressive .... lb. per sq. in.	26.5×10^3	± 8	19
Tensile .... do.	5.5×10^3	±22	3
Flexural (modulus of rupture) ..... do.	2.9×10^3	±13	4
Impact toughness .... in. per sq. in.	3.1	±30	15
Hardness:			
Scleroscope units	84	±12	360
Abrasive ...... revolutions x sq. in. per lb.	51×10^{-3}	± 8	6
Elastic constants			
Dynamic:			
Young's modulus .... lb. per sq. in.	5.84×10^6	+17	10
Modulus of rigidity .... do.	2.80×10^6	±19	10
Specific damping capacity	.03	±38	10
Apparent Poissons ratio	.06	±97	10
Bar velocity (longitudinal)..... ft. per sec.	12.7×10^3	± 9	10
Bar velocity (torsional) .... do.	8.8×10^3	±10	10
Static:			
Compression:			
Young's modulus[2] at 17,400 lb. per sq. in.	7.67×10^6	±33	7
Poisson's ratio at 17,400 lb. per sq. in. .	.29	±21	7
Failure strain[3] .... in. per in.	$2,900 \times 10^{-6}$		7
Tension:			
Young's modulus[2] at 400 lb. per sq. in. ..	3.76×10^6	±44	3
Poisson's ratio at 400 lb. per sq. in.	.09	±69	3
Failure strain[3] .... in. per in.	185×10^{-6}		3

See footnotes at end of table.

TABLE 1. - Physical property data,[1] Camak quarry, Weston-Brooker Co. (Con.)

GROUP 2

(Test specimens parallel to foliation)

Property	Average value	Standard deviation, percent	Number of readings
Density:			
Apparent specific gravity	2.67	± 2	15
Density .... lb. per cu. ft.	167	-	-
Porosity .... percent	.68	±40	7
Strength:			
Compressive .... lb. per sq. in.	28.3x10^{3}	±12	35
Tensile .... do.	7.0x10^{2}	-	1
Flexural (modulus of rupture) ..... do.	2.7x10^{3}	±28	9
Impact toughness .... in. per sq. in.	2.8	±14	14
Hardness:			
Scleroscope units	83	±11	560
Abrasive ...... revolutions x sq. in. per lb.	64x10^{-3}	±27	7
Elastic constants			
Dynamic:			
Young's modulus .... lb. per sq. in.	8.16x10^{6}	± 3	11
Modulus of rigidity .... do.	3.34x10^{6}	± 2	11
Specific damping capacity	.01	±69	11
Apparent Poissons ratio	.22	±13	11
Bar velocity (longitudinal) .... ft. per sec.	15.1x10^{3}	± 2	11
Bar velocity (torsional) .... do.	9.6x10^{3}	± 2	11
Static:			
Compression:			
Young's modulus[2] at 20,000 lb. per sq. in.	7.71x10^{6}	±18	7
Poisson's ratio at 20,000 lb. per sq. in. .	.38	±29	7
Failure strain[3] .... in. per in.	2,900x10^{-6}		7
Tension:			
Young's modulus[2] at 600 lb. per sq. in. ..	4.51x10^{6}	-	1
Poisson's ratio at 600 lb. per sq. in.	.13	-	1
Failure strain[3] .... in. per in.	185x10^{-6}	-	1

[1] From unpublished report of Applied Physics Laboratory, Bureau of Mines, College Park, Md. Test procedures used are described in Bureau of Mines Rept. of Investigations 3891.

[2] Secant value at median load.

[3] Extrapolated from failure stress on stress-strain curves.

EXPLORATION AND ESTIMATION OF RESERVES

Observation of exposed granite outcrops and experience gained while quarrying supplied all the data needed for quarry-development plans up to the present. On the basis of expected geologic continuity of the formation, reserves of rock suitable for market requirements are virtually unlimited. The problem is to determine the area most favorable economically for future development. Factors to be considered are: Overburden to be removed; roads, powerlines, buildings, and other obstacles needing relocation; ownership of property; drainage and water table; and the vertical and horizontal distances over which rock must be transported to the processing plant.

Developed reserves are in the 3 lower 30-foot benches. Quarrying these to present quarry limits is calculated to supply about 11,000,000 tons of stone - an additional 8 years' operation. Further reserves can be added, either by lateral or vertical development. Undoubtedly, the choice will be greatly influenced by future market requirements and technologic changes.

DEVELOPMENT AND MINING

General

The upper bench is an extension of the original, natural-draining quarry floor, and the face averages about 65 feet in height for a distance of 4,100 feet. Three lower benches, each with a face 30 feet high, have been developed for distances of 2,300, 1,800, and 800 feet, respectively. A series of ramps at an 8 percent grade have been provided for movement of pit equipment from one level to the next. Total area contained within the quarry rim is about 52 acres and is roughly oval shaped, with a length of 2,100 feet and a width of 1,300 feet. Figures 1, 2, and 3 show the present quarry layout and the relation to the original granite outcrops.

All inflowing water in the quarry drains to a large sump in the quarry floor. An Allis-Chalmers centrifugal pump with an 8-inch suction and 6-inch discharge, powered by a 100-hp. electric motor, pumps 1,100 gallons of water per minute out of the sump to a point of natural drainage. Operation of the pump is variable. Continuous operation is required after heavy rains, but during dry periods pumping is not necessary. The average for the year is about 1 hour of pumping per day.

Removal of Overburden

During the first years of operation, the selected area had solid rock exposed at the surface, presenting no waste-removal problem. Further expansion necessitated removal of an average of 10 feet of residual material. Normally, 2 to 5 feet of weathered granite must be wasted. The overburden around part of the quarry rim and considerable distance beyond is about 25 feet thick; no additional expansion is being planned in these directions. A relatively small area of the quarry's western corner will be stripped of overburden; thereafter, no more stripping operations are planned.

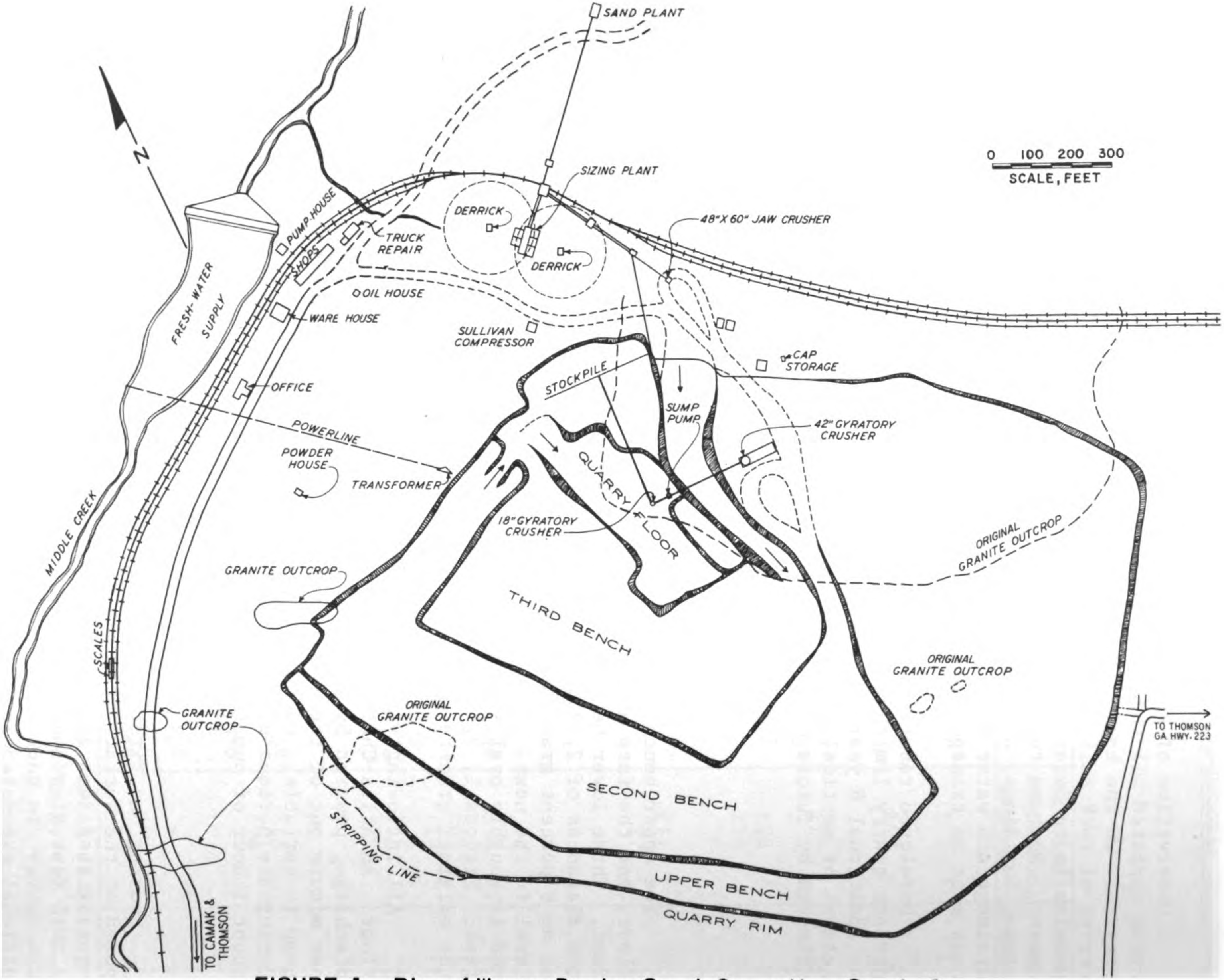

FIGURE 1. - Plan of Weston-Brooker Camak Quarry Near Camak, Ga.

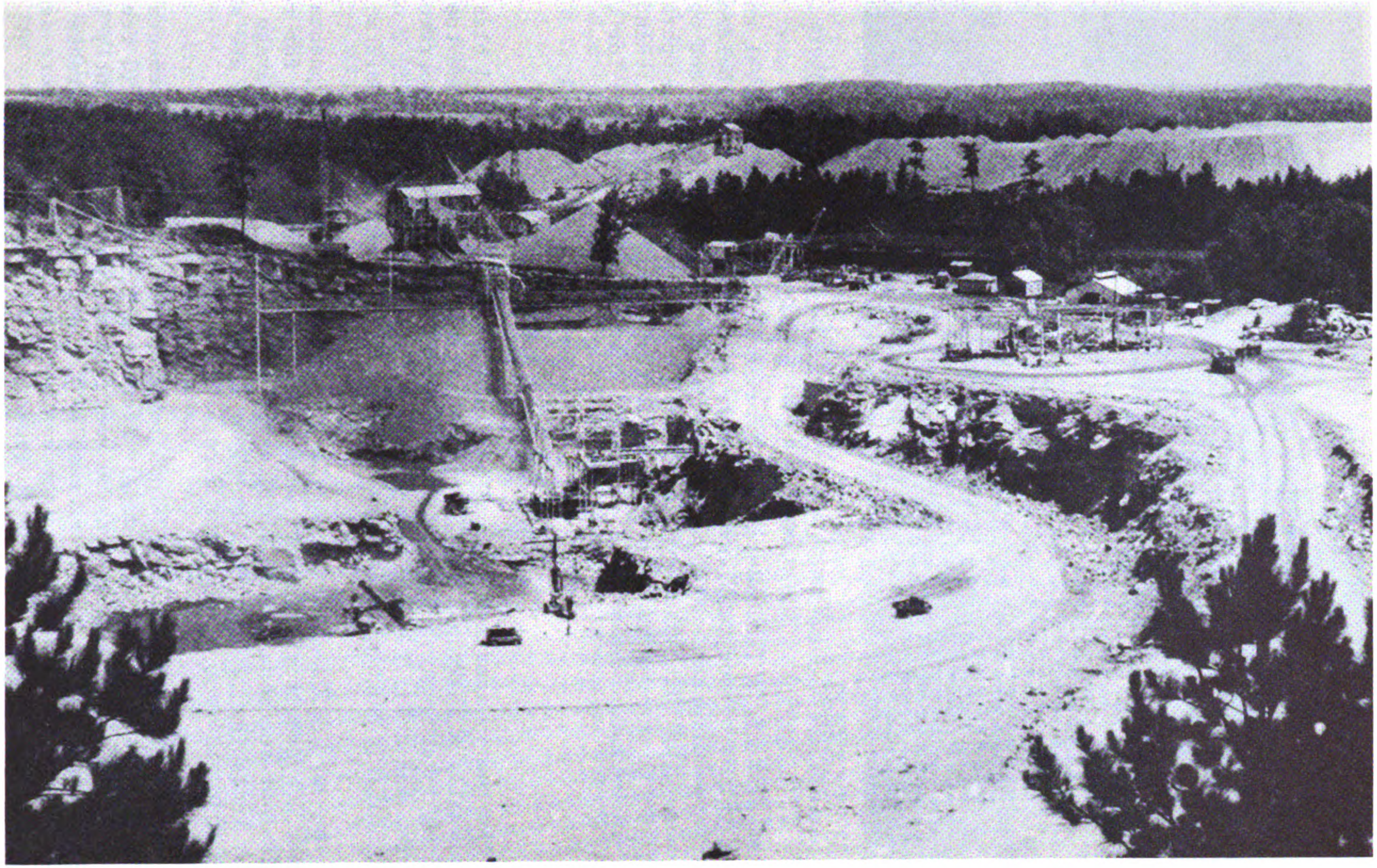

FIGURE 2. - View of Part of Quarry and Processing Plant.

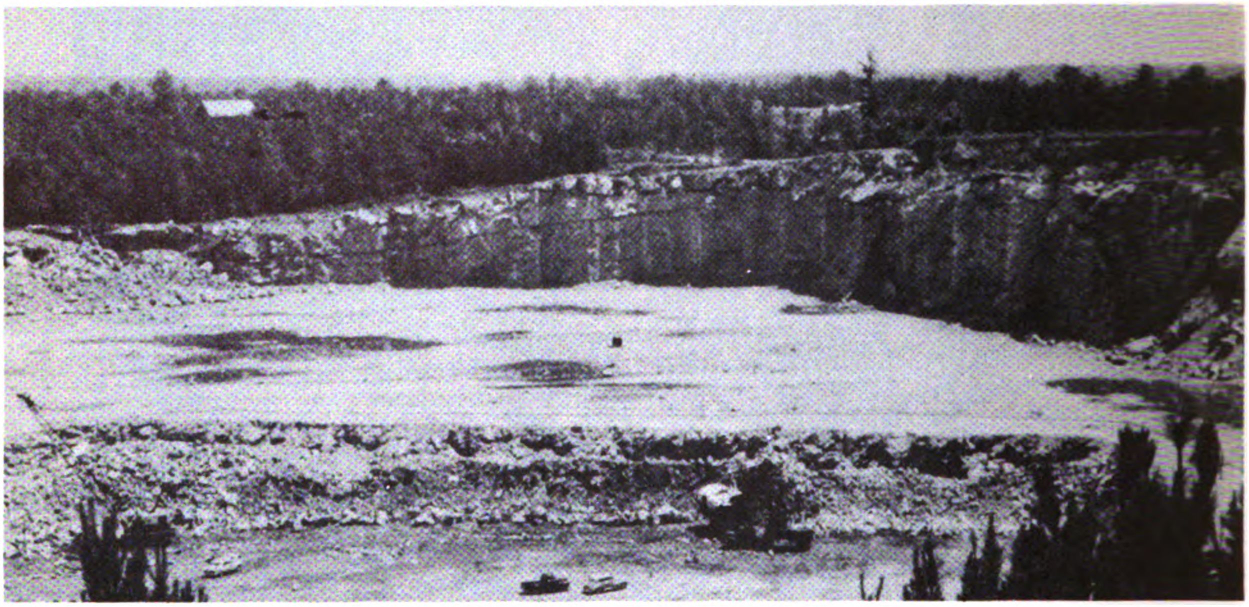

FIGURE 3. - View of Quarry Looking East Showing High Wall Above Upper Bench and Part of Second Bench.

At present, a 1-cubic-yard, Bucyrus-Erie 29B electric shovel and 3 F-8 Ford gasoline, 6-ton dump trucks remove and transport the overburden to connient disposal areas. When stripping is ended, the equipment and operators will move sand that has accumulated around the sand house. An operator and helper drill the weathered rock (saprolite), using an Ingersoll-Rand X-71, 3-1/2-inch-piston wagon drill. The pit foreman is responsible for the operation.

Primary Drilling and Blasting

The quarry face is advanced by drilling vertical holes and blasting. Occasionally a snakehole may be used to assist in breaking a bad toe. Drilling is accomplished by 2 Joy TM-500 drills, requiring 2 operators and 2 helpers, and 2 Joy TM-400, 4-inch-piston wagon drills, requiring 2 operators and 1 helper. Both machines use a 4-inch carbide bit with X points.

The Joy TM-500 drill is a self-propelled unit mounted on pneumatic tires and has a hydraulically raised mast equipped with an air winch for removing the 20-foot sectional, 2-inch diameter, hollow drill rods. Average drilling speed, including delays, is from 17 to 21 feet per hour. Bits are sharpened every 40 to 50 feet. They have a total life of about 400 feet.

The Joy TM-400 uses 1-1/2-inch round steel in 7-foot increments for drilling holes up to 30 feet deep. Average drilling speed is 10 feet per hour. Bits are sharpened every 30 feet; total footage is slightly less than for the larger drill. However, results are not directly comparable since the smaller drill is used in more inaccessible places, requiring more setup time, and the ground is more fractured, increasing bit wear.

Air compressors used for operating the primary drills, stripping, secondary drilling, and other plant usage are:

Make	Type	Motor, hp.	Capacity, c.f.m.	Power
Ingersoll-Rand..	Stationary	225	-	Electric
Sullivan	do.	200	-	Do.
Joy	do.	175	-	Diesel
2 Ingersoll-Rand	Portable	-	600	Do.
Jaeger	do.	-	315	Do.

During normal operation, the 600-c.f.m. portable compressors are used with the Joy TM-500 drills. The stationary compressors supply air for the wagon drills, and the 315-c.f.m. portable compressor is assigned to secondary drilling.

A normal blast on the 30-foot-high faces consists of 100 holes, 30 feet deep, arranged in a 3-row staggered hole pattern, with 15-feet spacing between holes, and 10 feet of burden. Each hole is first loaded with 50 pounds of Giant Gelatin (Atlas), 60-percent dynamite, followed by 70 pounds of Geoldyn No. 1, 55-percent dynamite, both packaged in 3-inch-diameter cartridges. The primer is made by placing an electric cap in the bottom cartridge. If the circuit proves defective, a second primer is placed near the top of the hole; in either case about 8 feet of stemming is placed on top. Alternate delays of 8 and 25 milliseconds are used in the first row, 50 and 75 millisecond delays in the second row, and 100 and 125 millisecond delays in the third row. Firing is by 220-volt powerline with 10 holes in series. Satisfactory fragmentation results from the blast, producing 3.1 tons of rock per pound of explosive. Figure 4 shows the hole pattern, spacing, detonator delays, and muckpile produced in a typical blast.

Secondary Breakage

It is estimated that 15 percent of the rock broken by primary blasting is too large to be handled by quarry equipment and requires further reduction by secondary breakage. This reduction is accomplished by use of a drop ball for two-thirds of the oversize and by jackhammer drilling and blasting for the other one-third.

A Marion 372 (1-1/2-cubic-yard rating) diesel-powered crane, shown in figure 5, is used for the drop ball work. Originally, a 6,000-pound, forged, drop ball was used. Currently, a cast, 8,000-pound, cylindrically shaped, drop ball is used. When it is worn to about 5,000 pounds, it is replaced with a new one. The life of the larger ball exceeds 1 year. Although actual comparative figures are not available, the wear per ton of stone broken is considerably less for the ball now being used. If moving the crane from one bench to the next did not take so long, it is possible that most of the secondary breakage could be handled by this machine. One man serves as operator and oiler.

The secondary drilling is done by four men using jackhammers. Two men are employed for secondary blasting and for loading and firing the primary

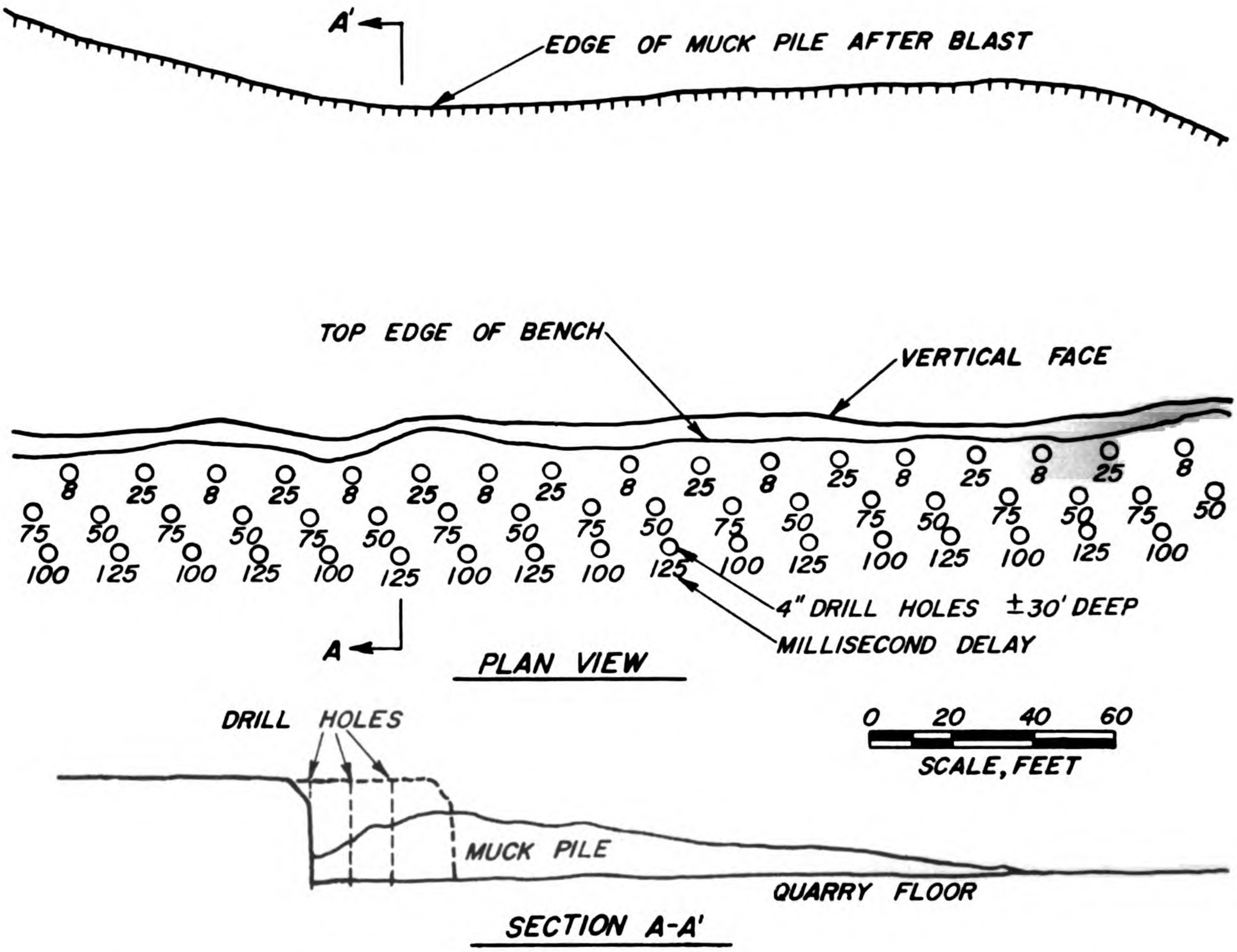

FIGURE 4. - Part of Quarry Blast Showing Hole Pattern, Spacing, Detonator Delays, and Shape of Muck Pile.

blasts. Giant Gel (Atlas), 30-percent dynamite, in 1- by 8-inch cartridges, is used for secondary blasting. Detonation is accomplished by using blasting fuse and caps. Estimated daily consumption of explosives for secondary breakage is 100 pounds of dynamite and 300 blasting caps. A foreman is in charge of secondary drilling and blasting operations.

Quarry Loading and Transportation

The four power shovels used to load the broken rock are as follows:

Make and model	Size, cubic yard	Fuel
Marion 482	2-1/4	Electric, 550 volts
Marion 492	3	Do.
Marion 362	1-1/2	Diesel
Bucyrus-Erie 85B	2-1/2	Electric, 550 volts

Original from THE OHIO STATE UNIVERSITY

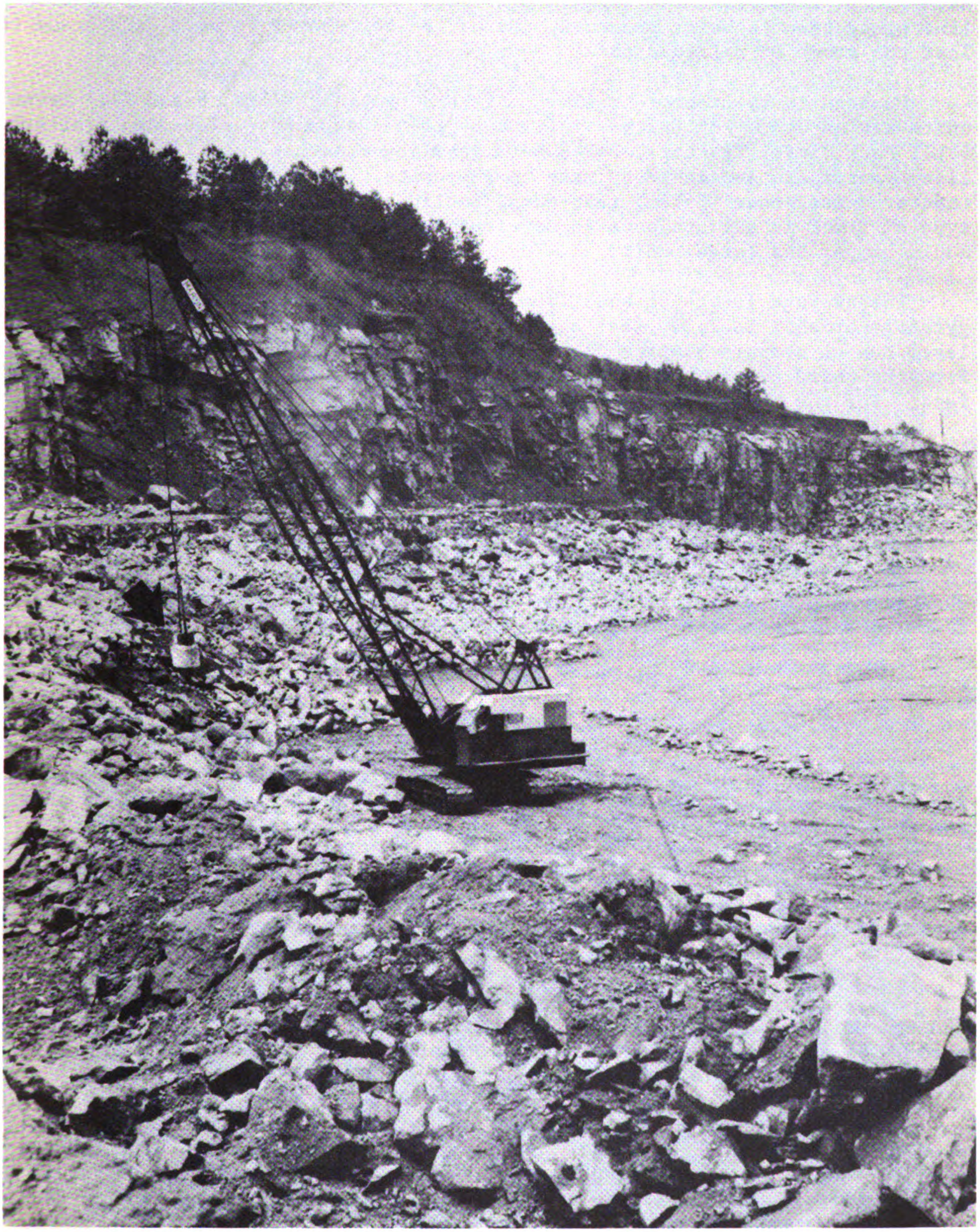

FIGURE 5. - Crane and Drop-Ball Unit (Arrow) for Secondary Breakage.

Each shovel requires an operator and helper. When large rock used in coastline protection is being produced, the Marion 362 shovel is used as a crane to load the stone on railroad cars.

Haulage is by tractor-trailer units and by truck (figs. 6 and 7). Seven units are in use. Ten Easton, twin-body, 15-ton capacity, side-dump trailers, 6 LJT Mack diesel tractors, 2 F-8 Ford gasoline tractors, and 1 E-Q Mack gasoline tractor are available to make up the units. In addition to the trailer-tractor units, four 15-ton, rear-dump, Euclid trucks are used. The use of this type of truck is advantageous in developing new levels where close sharp turns would hamper the larger unit.

The average length of haul from the active face on the upper level to the gyratory crusher is 2,300 feet and to the jaw crusher 2,800 feet. The second level has an average haulage distance of 1,400 and 1,900 feet, respectively. From the third level, the average haul to either crusher is approximately 1,400 feet. For the lowest level, this distance is about 2,300 feet.

Plans are to relocate the primary crusher at a lower elevation and more central location as soon as development on the lowest level provides the necessary space. This change will materially reduce the length of haul and amount of adverse grade that the trucks now have.

Two bulldozers are used to keep flyrock and spillage pushed up into the muckpile and to maintain the roads. An additional employee operates a water truck to wet down the roads and performs other miscellaneous pitwork.

PROCESSING

General

Processing includes crushing, sizing, storing, washing, blending, and loading the stone in preparation for market requirements. Figures 9 and 10 show the physical layout and flow of material described in this section.

Horizontal and inclined transportation of crushed stone to equipment, storage pile, or loading point is by 18- to 42-inch belt conveyors. The storage bridge, sizing plant, and all conveyor structures are of open-steel construction.

A 42-inch Superior-McCully gyratory crusher, driven by a 250-hp. motor, and the original 48- by 60-inch Allis-Chalmers jaw crusher, driven by a 200-hp. motor, are used for primary crushing. Repairs are required about every 5 months for the gyratory crusher and every 6 months for the jaw crusher.

Secondary crushing is by two Superior-McCully gyratory crushers. The product from the 42-inch gyratory crusher feeds an 18-inch crusher while the product of the jaw crusher feeds a 20-inch crusher. The 18-inch crusher is powered by a 200-hp. motor and the 20-inch crusher by a 100-hp. motor. Each crusher needs repairs about every 5 to 6 months.

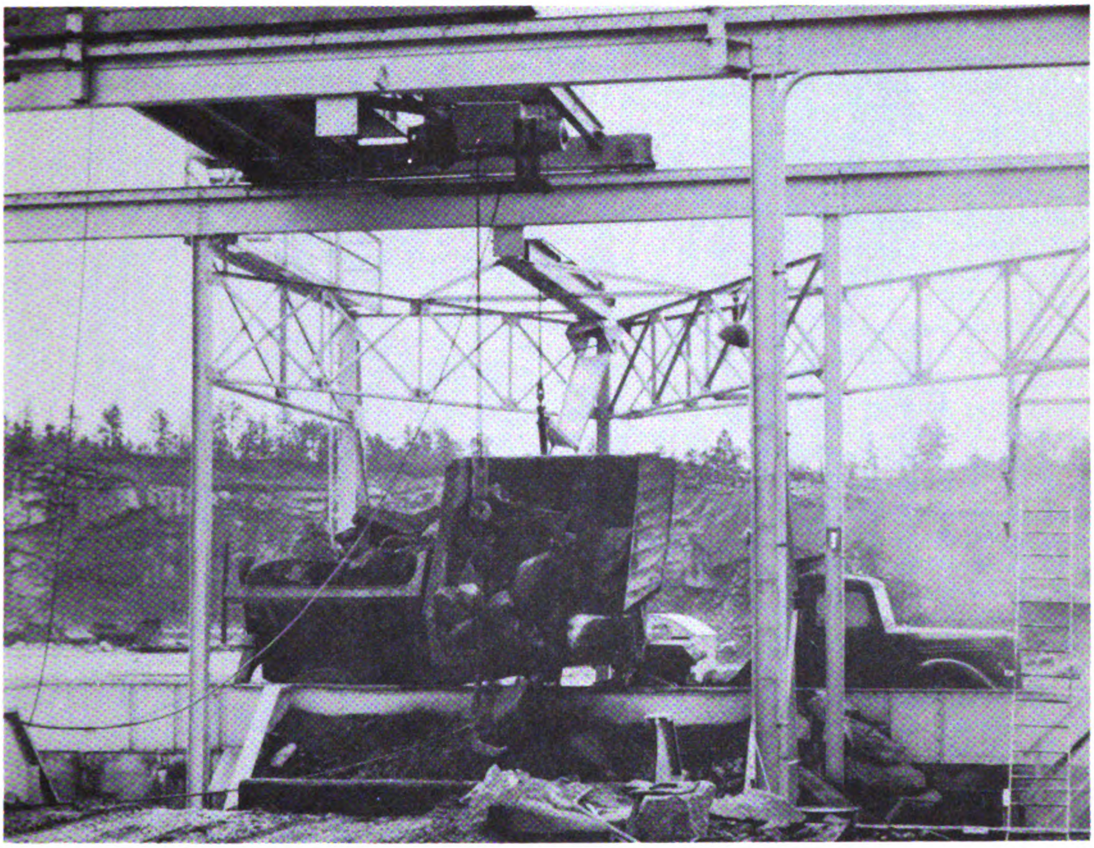

FIGURE 6. - Side-Dump Tractor-Trailer Unit Discharging Into Gyratory Crusher.

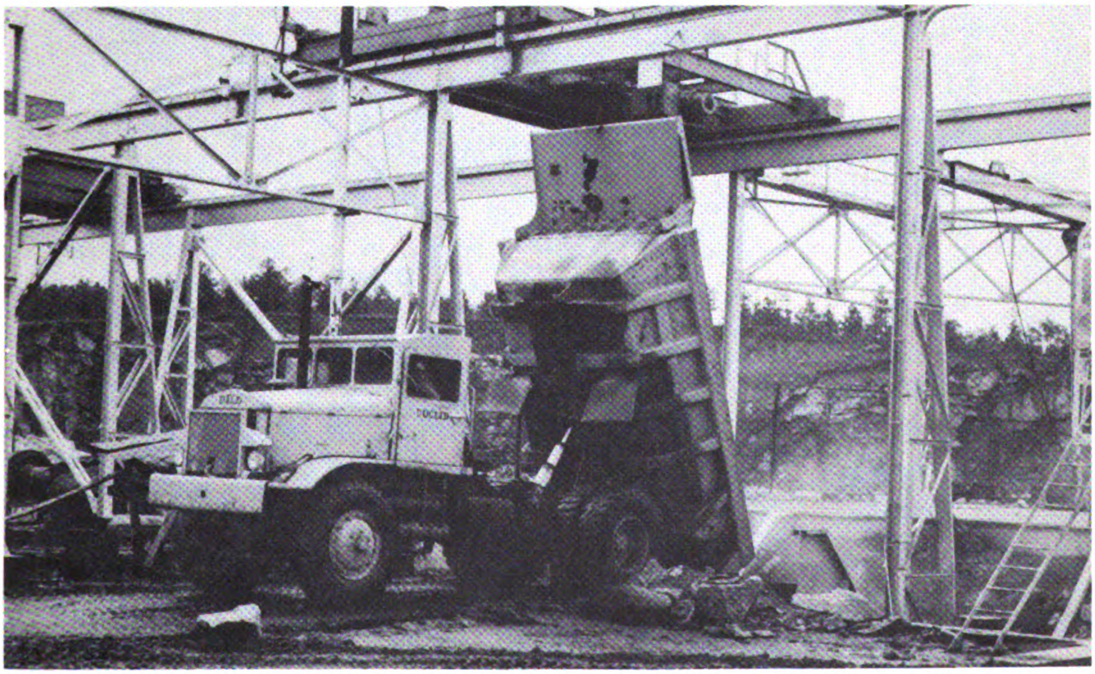

FIGURE 7. - End-Dump Truck Discharging Into Crusher.

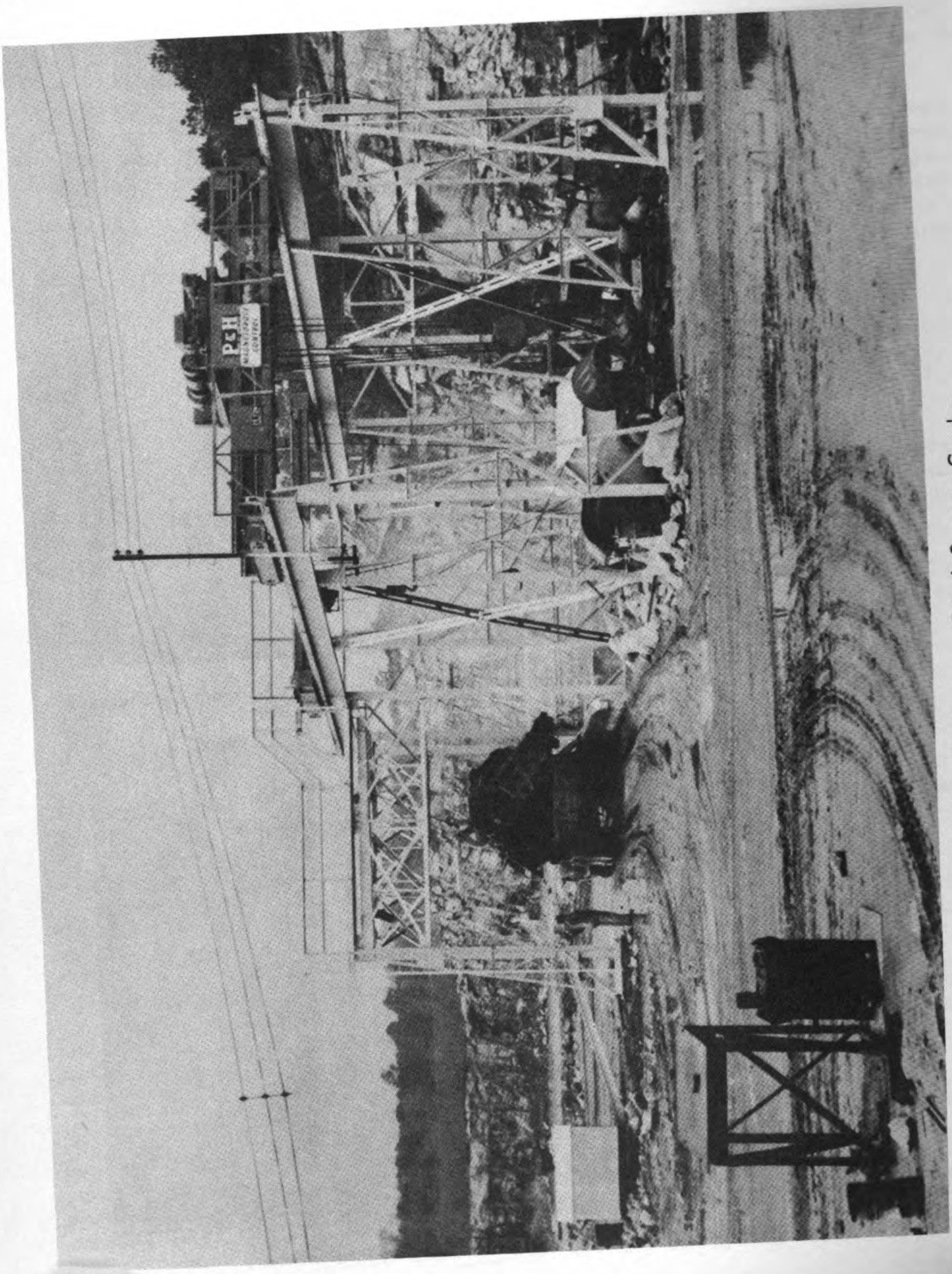

FIGURE 8. - Primary 42-Inch Gyratory Crusher.

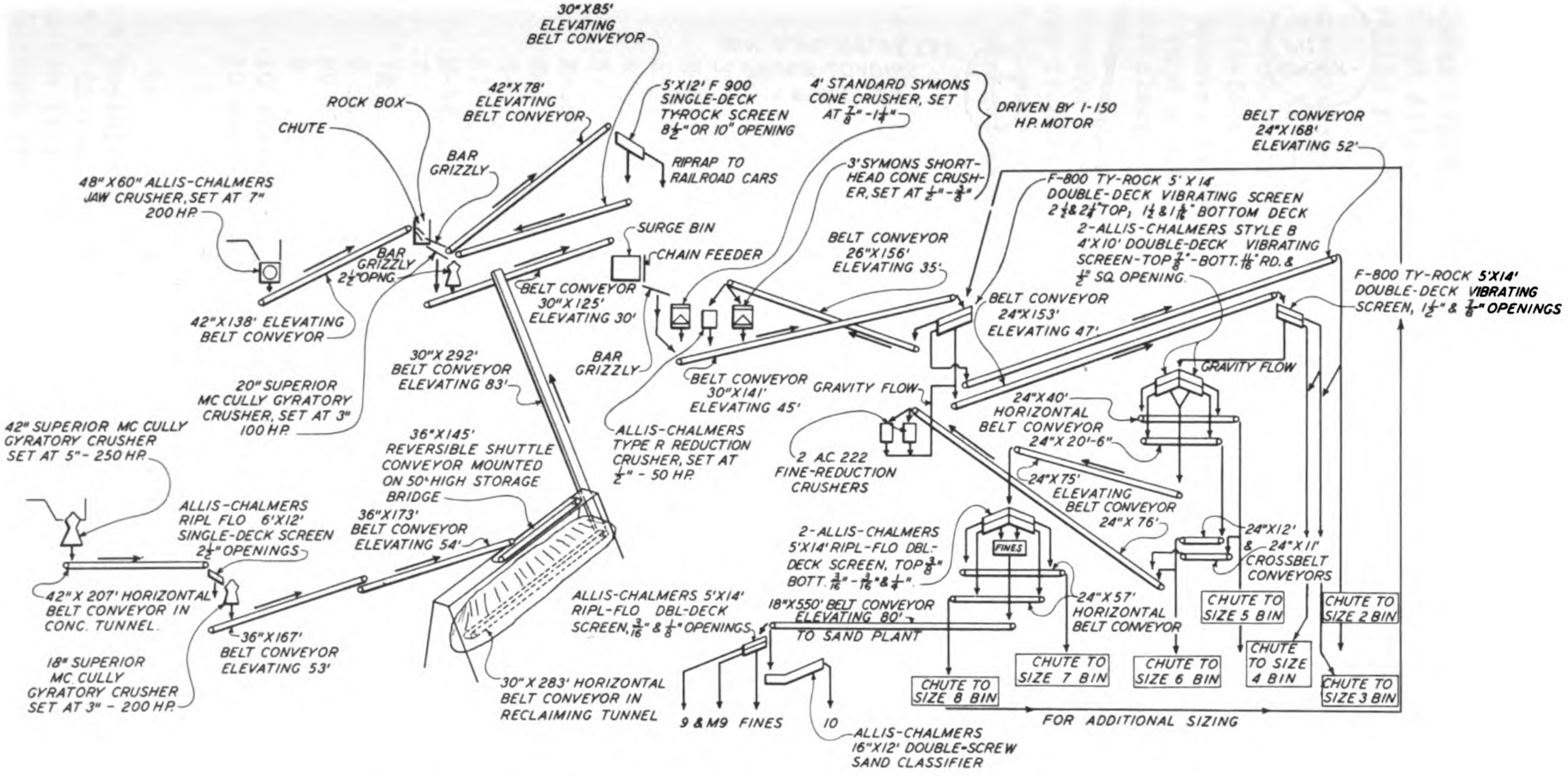
30"X85' ELEVATING BELT CONVEYOR
ROCK BOX
CHUTE
42"X78' ELEVATING BELT CONVEYOR
BAR GRIZZLY
5'X12' F 900 SINGLE-DECK TYROCK SCREEN 8½" OR 10" OPENING
RIPRAP TO RAILROAD CARS
4' STANDARD SYMONS CONE CRUSHER, SET AT ⅞"-1¼"
DRIVEN BY 1-150 HP. MOTOR
BELT CONVEYOR 24"X168' ELEVATING 52'
48"X60" ALLIS-CHALMERS JAW CRUSHER, SET AT 7" 200 HP.
BAR GRIZZLY 2½" OPNG.
SURGE BIN
CHAIN FEEDER
3' SYMONS SHORT-HEAD CONE CRUSHER, SET AT ½"-⅜"
F-800 TY-ROCK 5'X14' DOUBLE-DECK VIBRATING SCREEN 2½ & 2¼" TOP, 1½ & 1 1/16" BOTTOM DECK
2-ALLIS-CHALMERS STYLE B 4'X10' DOUBLE-DECK VIBRATING SCREEN-TOP ⅞"-BOTT. 11/16" RD. & ½" SQ. OPENING.
BELT CONVEYOR 26"X156' ELEVATING 35'
F-800 TY-ROCK 5'X14' DOUBLE-DECK VIBRATING SCREEN, 1½" & ⅞" OPENINGS
42"X138' ELEVATING BELT CONVEYOR
BELT CONVEYOR 30"X125' ELEVATING 30'
BELT CONVEYOR 24"X153' ELEVATING 47'
30"X292' BELT CONVEYOR ELEVATING 83'
BAR GRIZZLY
20" SUPERIOR MC CULLY GYRATORY CRUSHER, SET AT 3" 100 HP.
BELT CONVEYOR 30"X141' ELEVATING 45'
GRAVITY FLOW
GRAVITY FLOW
24"X40' HORIZONTAL BELT CONVEYOR
24"X20'-6"
42" SUPERIOR MC CULLY GYRATORY CRUSHER SET AT 5"-250 HP.
36"X145' REVERSIBLE SHUTTLE CONVEYOR MOUNTED ON 50' HIGH STORAGE BRIDGE
ALLIS-CHALMERS TYPE R REDUCTION CRUSHER, SET AT ½"-50 HP.
2 A.C. 222 FINE-REDUCTION CRUSHERS
24"X75' ELEVATING BELT CONVEYOR 24"X76'
ALLIS-CHALMERS RIPL FLO 6'X12' SINGLE-DECK SCREEN 2½" OPENINGS
36"X173' BELT CONVEYOR ELEVATING 54'
2-ALLIS-CHALMERS 5'X14' RIPL-FLO DBL.-DECK SCREEN, TOP ⅜" BOTT. 3/16"-3/16" & ¼".
FINES
24"X12' & 24"X11' CROSSBELT CONVEYORS
42"X207' HORIZONTAL BELT CONVEYOR IN CONC. TUNNEL.
ALLIS-CHALMERS 5'X14' RIPL-FLO DBL-DECK SCREEN, 3/16" & ⅛" OPENINGS
18"X550' BELT CONVEYOR ELEVATING 80' TO SAND PLANT
24"X57' HORIZONTAL BELT CONVEYOR
CHUTE TO SIZE 5 BIN
CHUTE TO SIZE 2 BIN
36"X167' BELT CONVEYOR ELEVATING 53'
CHUTE TO SIZE 7 BIN
CHUTE TO SIZE 6 BIN
CHUTE TO SIZE 4 BIN
18" SUPERIOR MC CULLY GYRATORY CRUSHER SET AT 3"-200 HP.
30"X283' HORIZONTAL BELT CONVEYOR IN RECLAIMING TUNNEL
CHUTE TO SIZE 8 BIN
CHUTE TO SIZE 3 BIN
9 & M9 FINES
10
FOR ADDITIONAL SIZING
ALLIS-CHALMERS 16"X12' DOUBLE-SCREW SAND CLASSIFIER

FIGURE 9. - Flowsheet of Crushing and Screening Operations.

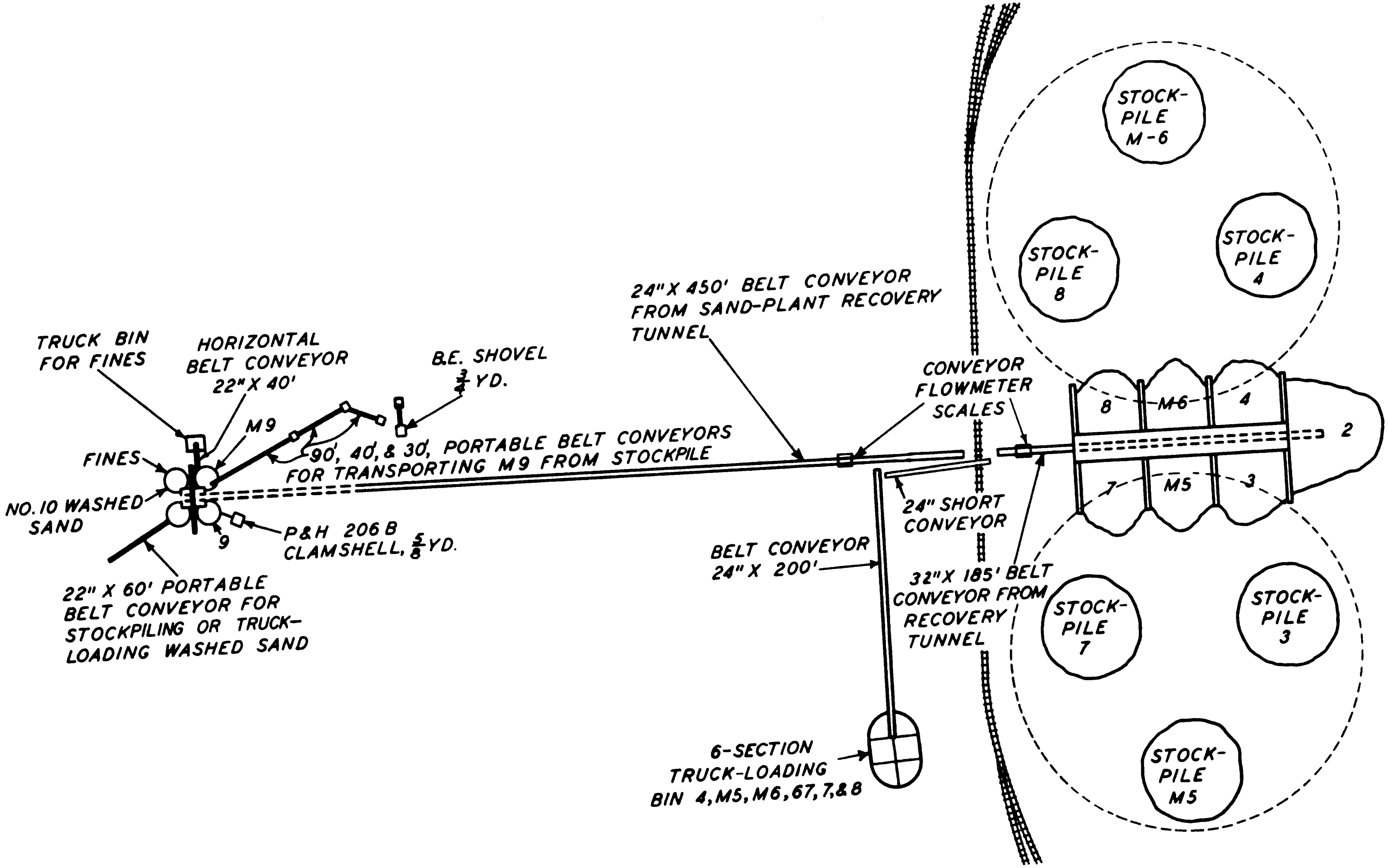
STOCK-PILE M-6
STOCK-PILE 4
STOCK-PILE 8
STOCK-PILE 7
STOCK-PILE 3
STOCK-PILE M5
8
M6
4
2
7
M5
3
24" X 450' BELT CONVEYOR FROM SAND-PLANT RECOVERY TUNNEL
CONVEYOR FLOWMETER SCALES
TRUCK BIN FOR FINES
HORIZONTAL BELT CONVEYOR 22" X 40'
B.E. SHOVEL $\frac{3}{4}$ YD.
M9
FINES
90', 40', & 30', PORTABLE BELT CONVEYORS FOR TRANSPORTING M9 FROM STOCKPILE
NO. 10 WASHED SAND
9
P&H 206 B CLAMSHELL, $\frac{5}{8}$ YD.
22" X 60' PORTABLE BELT CONVEYOR FOR STOCKPILING OR TRUCK-LOADING WASHED SAND
24" SHORT CONVEYOR
BELT CONVEYOR 24" X 200'
32" X 185' BELT CONVEYOR FROM RECOVERY TUNNEL
6-SECTION TRUCK-LOADING BIN 4, M5, M6, 67, 7, & 8

FIGURE 10. - Plan of Storage and Loading Operations.

Tertiary crushing is by a 4-foot standard Symons cone crusher; a 3-foot Symons short-head cone crusher, powered by one 150-hp. motor; and an Allis-Chalmers 530, type R, reduction crusher. The 4-foot standard Symons cone crusher requires repair about every 2 months and the 3-foot short-head Symons cone crusher and Allis-Chalmers 530 crushers every 3 months. Additional crushing in the sizing plant is by two Allis-Chalmers 222 fine-reduction crushers.

Three screens are used for separating the stone before it goes to the sizing plant: A Ripl-flo 6- by 12-foot screen before the 18-inch gyratory crusher, an F-900 Ty-Rock 5- by 17-foot screen for separating riprap, and an F-800, 5- by 14-foot, double-deck vibrating screen. In the sizing plant, screens are mounted above bins which straddle a reclaiming tunnel. Sizing units in the sand plant consist of an F-800, 5- by 14-foot, double-deck screen and an Allis-Chalmers, 16-inch by 12-foot, double-screw sand classifier.

Rated average capacity of the plant is about 650 tons per hour, and feed to the primary crusher is about 1,400,000 tons per year. An estimated 75 percent is sold as washed stone, riprap, and sand. The remaining 25 percent accumulates as minus-1/4-inch material, exceeding present market demand for this size.

The following is a list of the crushed-stone sizes produced for sale:

Size	Grading
2	2-1/2- to 3/4-inch
24	2-1/4- to 1/2-inch
3	2- to 1/2-inch
M-35	2- to 1/2-inch
357	2-inch to 4-mesh
4	1-1/2- to 3/4-inch
57	1-inch to 8-mesh
M-58	1-inch to 8-mesh
M-5	1- to 1/2-inch
M-6	3/4- to 3/8-inch
67	3/4-inch to 8-mesh
M-68	3/4-inch to 8-mesh
7	1/2-inch to 4-mesh
78	1/2-inch to 8-mesh
8	3/8-inch to 8-mesh
89	3/4-inch to 16-mesh
9	4- to 16-mesh
10 screenings	4-mesh down
10 washed granite sand	4- to 100-mesh

Primary Crushing

A 42-inch Superior McCully gyratory crusher, set at 5 inches, is mounted on grade with a 25-ton P & H overhead service crane and an Easton elbow-type dumping mechanism (fig. 8). The stone as it comes from the quarry is fed through the 42-inch crusher, and deposited on a 42-inch by 207-foot horizontal belt conveyor, and then passed over an Allis-Chalmers Ripl-flo, 6- by 12-foot, single-deck screen with 2-1/2-inch openings. The undersize is deposited onto a 36-inch belt below; while the oversize is fed through an 18-inch Superior McCully gyratory crusher, set at 3 inches, and also deposited onto the 36-inch belt (fig. 11).

Tandem 36-inch by 167- and 173-foot conveyors, joined by a transfer box, carry the entire flow to the center of a 50-foot-high storage bridge. From this point, a 36-inch by 145-foot, reversible, shuttle conveyor distributes the stone in the primary storage pile (fig. 12). Operating personnel consists of 4 men - 2 at the 42-inch crusher, 1 at the 18-inch gyratory crusher, and 1 cleanup man.

The original 48- by 60-inch Allis-Chalmers jaw crusher, still in service, is used to supplement the output of the new primary crushing plant and also for the production of 20- to 200-pound riprap. Quarried stone is dumped from side-dump trucks by a pushbutton-operated, Easton elbow-type truck dumper directly into the crusher, which is set at 7 inches for crushed stone and at a larger opening for riprap.

The discharge from the jaw crusher is transported by a 42-inch conveyor belt to a small boxlike chute called a rock box. When operating as a chute, the stone passes over a stationary grizzly to the 20-inch secondary crusher. When riprap is required, a gate is closed to stop flow to the crusher and the stone builds up in height until it discharges to the side onto a grizzly of large spacing. The undersize continues to feed the crusher while the oversize is transported by a 42-inch belt to an F-900 Tyler Ty-Rock, 5- by 12-foot screen (with either 8-1/2- or 10-inch openings) over which it is passed. The oversize, consisting mostly of 50- to 200-pound riprap, is dropped directly into the railroad car for shipment, while the undersize is returned by a 30-inch belt conveyor to the secondary crusher.

Secondary Crushing, Screening, and Storage

When crushed stone is required, the gate to the secondary crusher is opened, and material is passed over a stationary grizzly, 2-1/2-inch spacing. The minus fraction is chuted to a 30-inch belt. The plus fraction is crushed by a 20-inch Superior McCully gyratory crusher (adapted for secondary crushing and set at 3 inches) and then dropped to the 30-inch belt conveyor below.

Material in the primary storage pile is recovered by a variable-speed belt feeder and placed on a 30-inch by 283-foot horizontal belt in the recovery tunnel. This material is then elevated to a height of 83 feet on a 30-inch by 292-foot belt conveyor, deposited onto the 30-inch belt from the 20-inch crusher, and discharged into a 200-ton surge bin.

The material then passes by means of a chain feeder over a grizzly with 2-1/2-inch openings, the oversize dropping into a 4-foot standard Symons cone crusher, set at 7/8 to 1-1/4 inches. A 30-inch belt conveyor transports both bypassed and crushed stone to an F-800 Tyler Ty-Rock, 5- by 14-foot, double-deck screen, with 2-1/2- and 2-1/4-inch openings in the top deck and 1-1/2- and

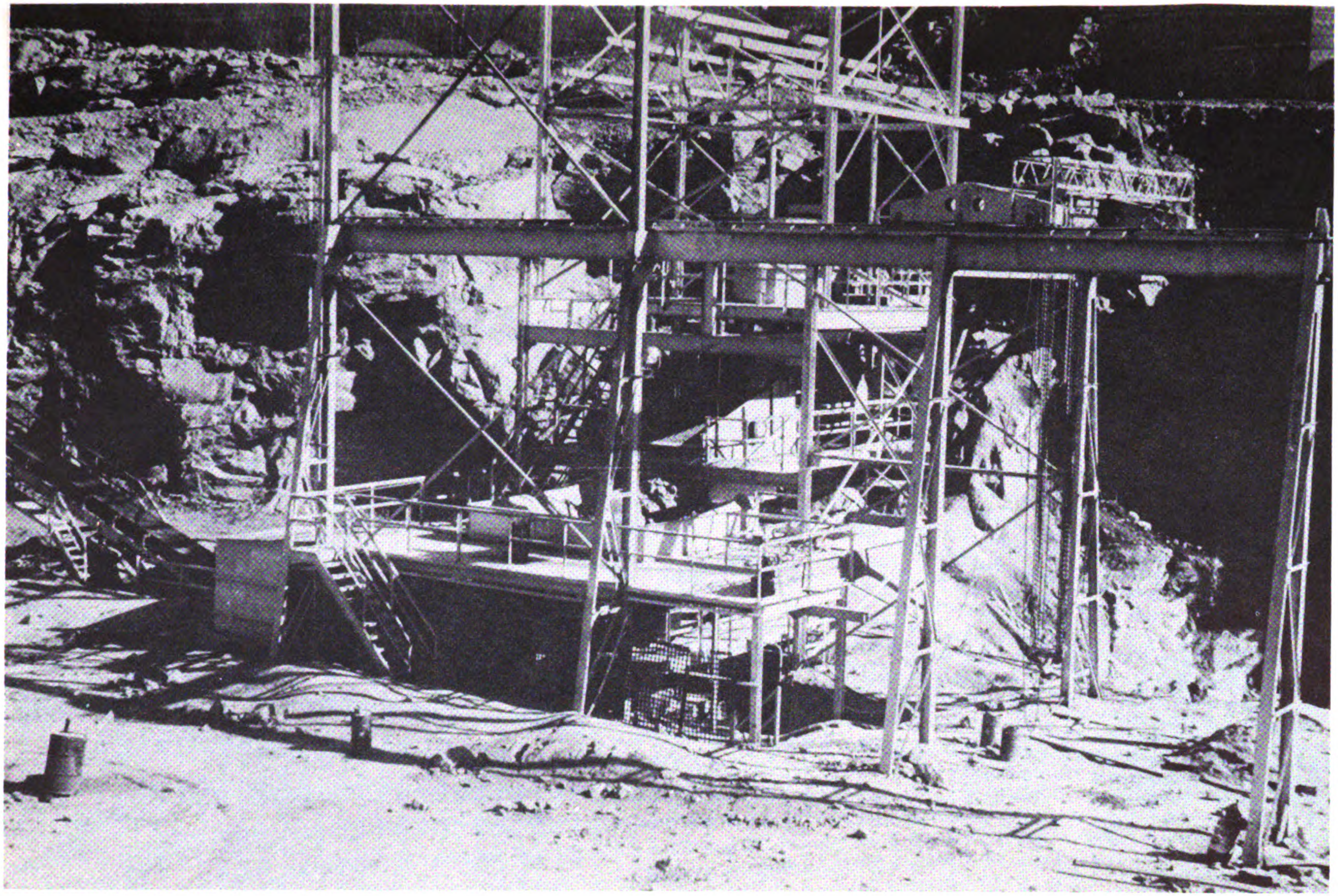

FIGURE 11. - Crushing Station for 18-Inch Gyratory Crusher.

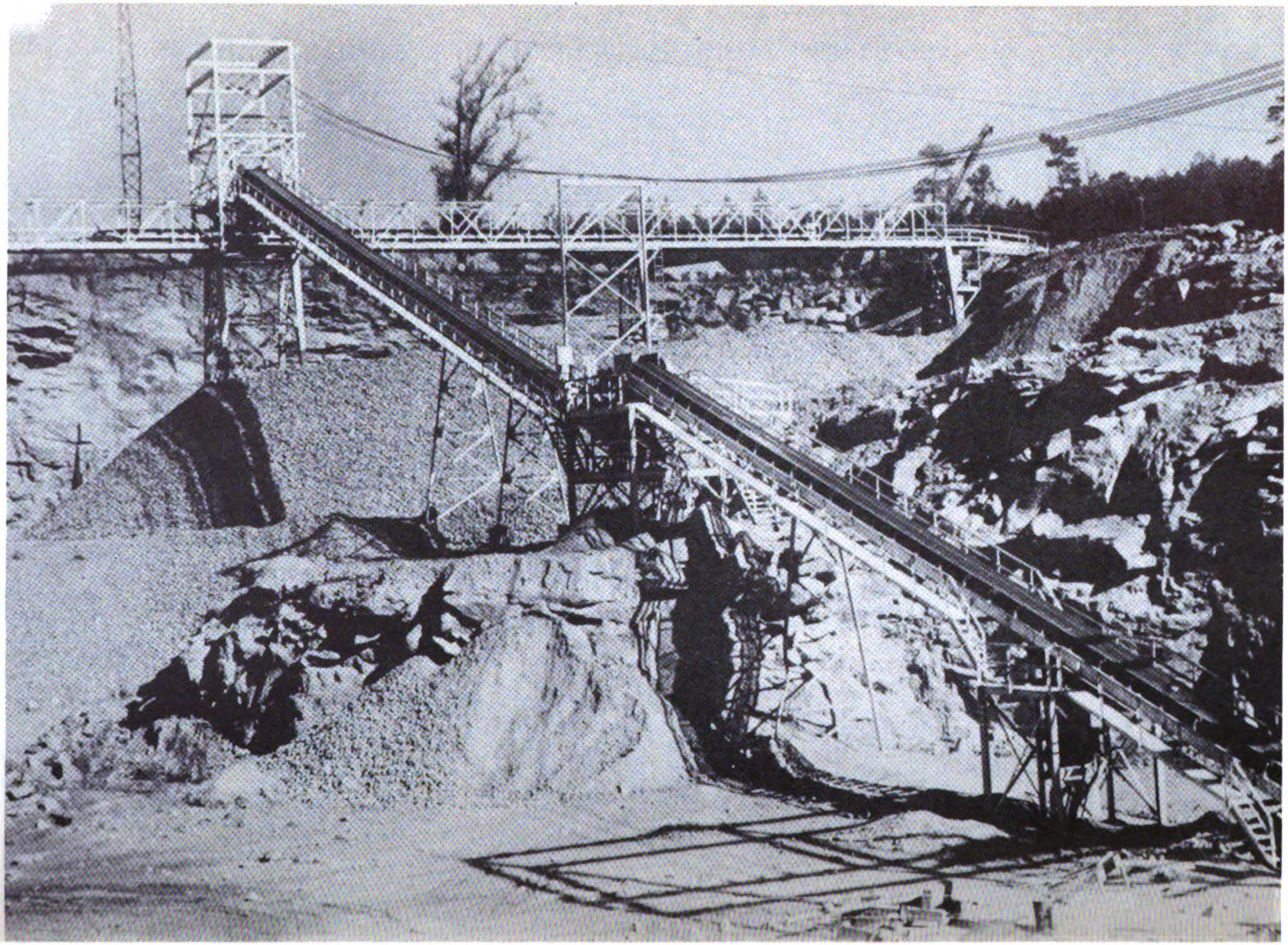

FIGURE 12. - Storage Pile for Plant Feed.

1-5/16-inch openings in the bottom deck. The plus-2-1/2-inch size is returned on a 26-inch belt and split between a 3-foot Symons short-head cone crusher, set at 1/2 - 3/8 inch, and an Allis-Chalmers, 530, type R, reduction crusher set at 1/2 inch. These units function as tertiary crushers and discharge onto the 30-inch belt which feeds the above mentioned F-800 screen, forming a closed circuit.

On the day shift, 1 operator is stationed at the 20-inch gyratory crusher, 1 in the reclaiming tunnel, and 1 at the tertiary crushers; also 1 cleanup man is required. On the night shift, the crusher operator is not needed.

The sizing-plant screens, mounted above bins which straddle a reclaiming tunnel, are fed by 2 belt conveyors from the F-800 screen. Intermediate gradation from the screen is elevated to the top and opposite end of the sizing plant by a 24-inch (5-A) belt conveyor and dropped by chute to either the size 2 or 3 bin. The undersize gradation is fet onto another 24-inch belt (5-B), which travels underneath the 5-A belt, and passed over an F-800 Tyler Ty-Rock, 5- by 14-foot, double-deck screen, with 1-1/2-and 7/8-inch openings. The oversize is conveyed by chute to either the size 3 or size 4 bin. The intermediate is conveyed to the size 4 bin.

The undersize is fed by gravity to 2 Allis-Chalmers, style B, 4- by 10-foot, double-deck screens in parallel which have 7/8-inch openings in the top deck and 11/16-inch round and 1/2-inch square openings in the bottom deck. The oversize is fed onto a 24-inch belt and either dropped by chute to the size 5 bin or deposited on a short 24-inch belt and transported to the opposite side of the sizing plant where it is fed onto another 24-inch belt to the reduction crushers.

The intermediate gradation is transported by a 24-inch belt, then by a short 24-inch crossbelt, and either dropped by chute to the size 6 bin or diverted by chute onto another 24-inch belt where both the oversize and intermediate are elevated and split between 2 Allis-Chalmers 222 reduction crushers. The product is then chuted onto the 5-B belt conveyor and again passed through the screen plant, forming a closed circuit.

The undersize from the 2 Allis-Chalmers, style B, screens is elevated by a 24-inch belt conveyor and then is split and passed over 2 Allis-Chalmers Ripl-flo, 5- by 14-foot, double-deck screens in parallel. The top deck has 3/8-inch openings, and the bottom deck is divided into two 3/16- and one 1/4-inch screen sections. Two 24-inch horizontal belts transport the oversize and intermediate gradations to their respective bins, sizes 7 and 8. The minus-1/4-inch material is stored in 2 bins below and transported to the sand house on an 18-inch by 550-foot belt conveyor.

Four size gradations - M-9, 9, 10 washed sand, and fine screenings - are produced at the sand house. An Allis-Chalmers Ripl-flo, 5- by 14-foot, double-deck screen, with 3/16- and 1/8-inch openings, is used for the sizing, and an Allis-Chalmers, 16-inch by 12-foot, double-screw sand classifier is used for the washed sand. The size 10 screenings may be dropped by chute to a stockpile or transported to a truck bin on a 22-inch horizontal belt for field storage.

Portable belt conveyors are used to move the several gradations from the bins to storage piles around the sand house.

The operating personnel for the sizing plant and screen house includes 4 employees on each of the 2 shifts - 2 truck drivers, 1 sizing-plant operator, and 1 sand-house operator. A foreman and an assistant foreman have charge of all crushing, sizing, and storage operations.

Blending and Loading

Two 1-1/2-cubic-yard guyed derricks, one on each side of the sizing plant, remove finished material from the bins for field storage and refill the bins when it is desired to ship from the stockpiles (figs. 1 and 10).

Each of the 7 different grades of crushed stone is reclaimed from its bin by chute and deposited onto a 32-inch by 185-foot belt in the recovery tunnel. The material is weighed while being transported by conveyor flowmeter scales. While being fed over scalping screens, it is washed with water sprays to remove the excess fines before dumping into rail cars at the rail-loading station (fig. 13). Material may be diverted by chute to conveyor 5-B and passed through the sizing plant again for additional gradation, or it may be diverted to another 24-inch belt conveyor and transported to a 6-section truck storage bin (fig. 14). Stone from this bin is loaded into trucks and weighed by platform scales near the main office.

Material in field storage around the sand house is loaded into trucks using either portable belt conveyors, a 5/8-cubic-yard clamshell crane, or a 3/4-cubic-yard shovel.

Material in bins beneath the sand house is fed by chute onto a 24-inch by 450-foot belt conveyor and transported to the rail-loading head for shipment. These bins are refilled from nearby field storage piles by portable belt conveyors.

Personnel for the loading operation consists of a foreman with a 7-man crew on the day shift and a foreman with a 6-man crew on the night shift. A testing engineer is employed to sample and test each shipment to make certain that the blending results in the properly specified sizes.

MAINTENANCE AND REPAIR

Maintenance and repair are important items of expense in producing crushed stone. The rock is very abrasive, and the large sizes handled up to the secondary crushing stage also cause high impact damage.

All maintenance and repair is done in shops on the property or at the machine site. Ten men are assigned to the maintenance crew - 2 auto mechanics, 2 welders, 1 machinist, 1 compressor man, and 4 helpers. The operators also assist in repairing their own machines.

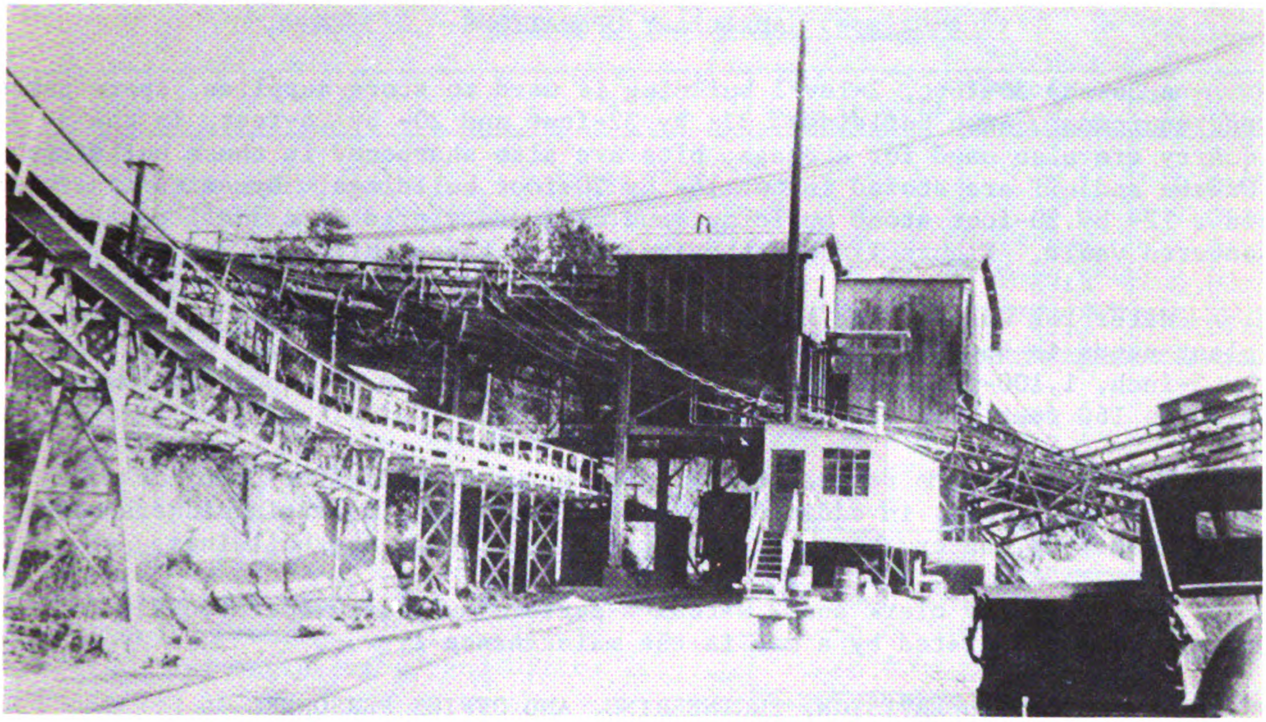

FIGURE 13. - Rail-Loading Station.

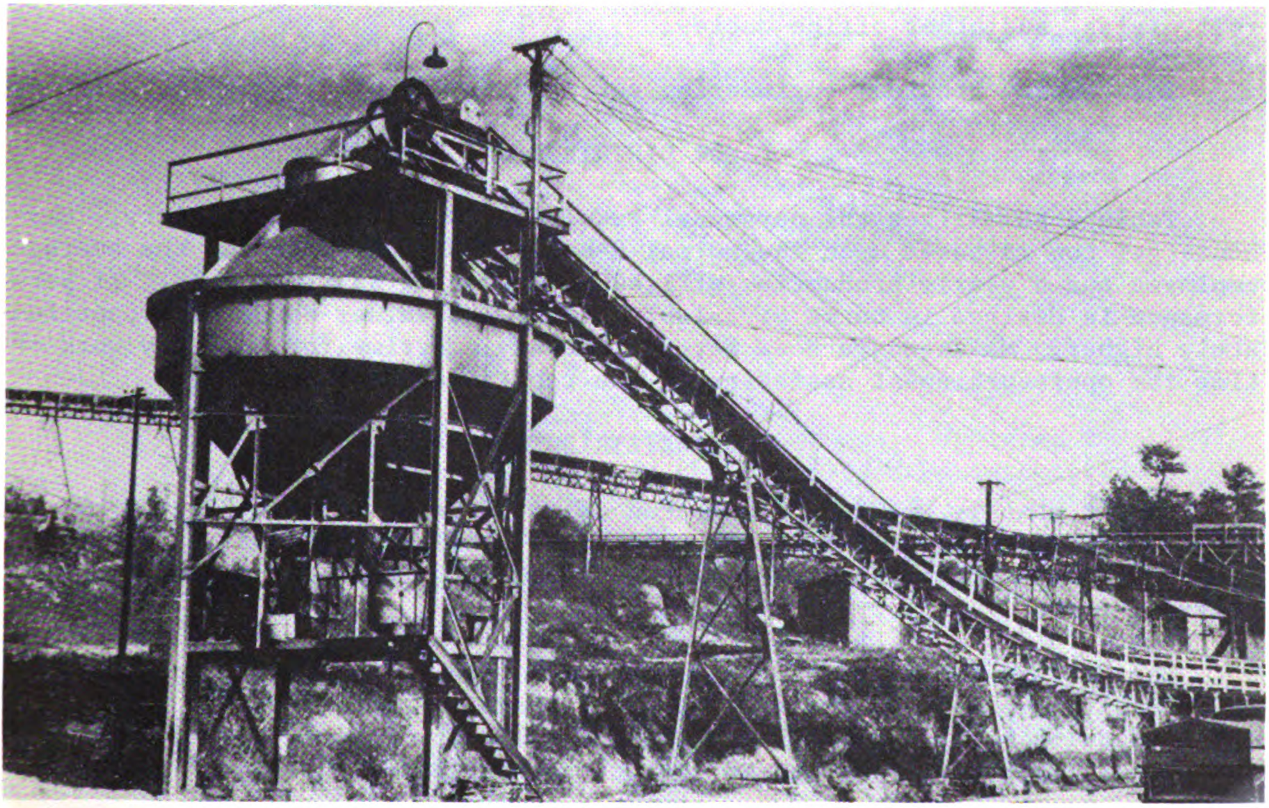

FIGURE 14. - Bin for Loading Trucks With Crushed Stone.

AUXILIARY OPERATIONS

A 36- by 36-foot, 2-level building is used to store supplies, spare parts, and equipment. Two buildings, 32- by 32-feet and 20- by 26-feet, in the quarry are also used for storage; bits are also sharpened in these buildings. Grease and oil are stored in two 14- by 20-foot buildings. Dynamite is stored in a 12- by 20-foot stone building, and caps are stored in a small earth-covered vault. Figure 1 shows the location of these buildings.

Water for washing the stone, wetting down loads, and other miscellaneous plant needs is supplied by a pond formed by a dam across Middle Creek. A 6- by 5-inch, 1,100-g.p.m. pump and a 5- by 4-inch, 750-g.p.m. pump are used to provide 160 feet head of water.

Fire hazards are reduced by building structures of fire-proof or fire-resistant materials, in addition to use of approved fire extinguishers mounted on all shovels, at crushers, and throughout the shops and buildings.

One inventory clerk and 2 watchmen perform auxiliary operations. The water pump is operated by a man in the maintenance crew.

SUPERVISION, ENGINEERING, AND OFFICE PERSONNEL

A plant superintendent and an assistant superintendent supervise all operations. An office force of four is assigned to purchasing, accounting, payroll, sales, and other office duties.

The company provides engineering services from their Cayce, S. C. office.

LABOR DISTRIBUTION

Table 2 summarizes the personnel requirements at the Camak quarry. Man-hours per ton is based upon the normal 9-hour, 5-day workweek for the average employee and a yearly production of 1,400,000 tons of quarried rock. If performance is desired in terms of salable stone, the values would be proportionately higher. Maintenance does not reflect any overtime for Saturday work or time the operators spent assisting in the repair of their machines.

POWER DISTRIBUTION

Recent monthly average consumption of electricity totaled 325,000 kw.-hr. and liquid fuels amounted to 3,481 gallons of gasoline and 7,314 gallons of fuel oil. This converts to 2.79 kw.-hr. and 0.30 gallon of fuel per ton of quarried rock.

The Georgia Power Co. supplies the Camak plant with electric power - 44,000-volt, 3-phase, 60-cycle current. Voltage is reduced to 550 volts for all production motors except 5 small 1- to 1-1/2-hp. motors that operate on 220 volts. Voltage is reduced to 110 volts for plant lighting.

TABLE 2. - Summary of personnel requirements

	Employees[1]	Percent of total	Man-hours per ton
Mining:			
Removal of overburden	6.2	6.1	0.0103
Primary drilling and blasting	8.2	8.0	.0137
Secondary breakage	7.0	6.9	.0117
Quarry loading and transportation	22.6	22.2	.0378
Total, mining	44.0	43.2	.0735
Processing:			
Primary crushing	6.6	6.5	.0110
Secondary and tertiary crushing	7.7	7.5	.0129
Screening and storage	8.7	8.5	.0145
Blending and loading	16.0	15.7	.0267
Total, processing	39.0	38.2	.0653
Maintenance and repairs	10.0	9.8	.0167
Auxiliary operations	3.0	2.9	.0050
Supervision, engineering, and office	6.0	5.9	.0100
Grand totals	102.0	100.0	.1705

1/ Foreman's time is pro-rated according to number of employees in each section, where foreman is not specifically assigned to a section.

A breakdown of power requirements in hp.-hours per ton of quarried stone for quarrying and processing operation follows:

Item	Hp. - hr. per ton[1]
Shovels	0.85
Trucks	2.40
Drilling (air compressors)	.81
Pumps	.61
Crushers	1.08
Screens	.20
Conveyors	.83
Total	6.78

1/ Based on rated hp. of equipment and hours operated x 0.65 (factor is metered kw.hr. divided by calculated kw.hr. with the same factor also applied to liquid-fuel-operated equipment).